REMARKS

Claims 1 through 6 have been cancelled and Claims 7 through 12 have been added and are currently pending in the present application. In view of the above amendment, applicant believes the pending application is in condition for allowance.

Thus, prompt and favorable consideration of this amendment is respectfully requested. If the Examiner believes that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at (248) 641-1600.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 08-0750, under Order No. 6340-000072/US/NP from which the undersigned is authorized to draw.

Dated: May 5, 2006

Respectfully submitted,

By W.R. Duke Taylor

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BEARING APPARATUS FOR A WHEEL OF VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a National Stage of International Application No. PCT/JP2004/015843, filed October 26, 2004, which claims priority to Japanese Patent Application No. 2003-375104, filed November 5, 2003. The disclosures of the above applications are incorporated herein by reference.

FIELD ~~BACKGROUND OF THE INVENTION~~

~~[0001]~~

~~Field of the Invention~~

[0002] The present ~~invention~~disclosure relates to a bearing apparatus for a wheel of a vehicle for rotatably supporting a wheel of the vehicle relative to a suspension system, and more particularly, to a bearing apparatus for a wheel of a vehicle intended to improve the durability of an inner ring fitted onto a ~~hub wheel~~wheel hub, and a method for manufacturing the bearing apparatus.

BACKGROUND

~~[0002]~~

~~Description of background Art~~

[0003] There are two types of bearing apparatus for a wheel of a vehicle, ~~e.g. such as those~~ One for a driving wheel and one for a driven wheel. ~~and improvements in~~ Improvements have been made to reduce~~reduction of~~ manufacturing cost and to reduce the size and ~~reduction of~~ weight of the bearing apparatus in order to improve~~and size for improving~~ fuel consumption~~have been achieved~~. One

representative example of such a bearing apparatus of the prior art, which is athe so-called a third generation type, is shown in Fig. 6.

[0003]

[0004] The bearing apparatus of thea wheel of the vehicle of Fig. 6 has a hub wheelwheel hub 51, an inner ring 52, an outer ring 53, and double row rolling elements 54, 54. The hub wheelwheel hub 51 has aan integrally formed wheel mounting flange 55 for mountingto mount a wheel (not shown) formed integrally therewith at one end. An thereof, an inner raceway surface 51a is formed on the outer circumferential surface of the wheel hub 51. A, and a cylindrical portion 51b axially extendingextends from the inner raceway surface 51a. Hub bolts 56, to secure for securing the wheel on the flange 55, are equidistantly arranged along the periphery of the flange 55. The inner ring 52 is press-fittedfit onto the cylindrical portion 51b of the hub wheelwheel hub 51. The inner ring 52 includes, and is formed on its outer circumferential surface, with an inner raceway surface 52a. The inner ring 51 is prevented from being axially slippedslipping off from the cylindrical portion 51b of the hub wheelwheel hub 51 by a caulked portion 51c. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion 51b of the hub wheelwheel hub 51.

[0004]

[0005] ——The outer ring 53 has aan integrally formed body mounting flange 53b integrally formed therewith and. Doubledouble row outer raceway surfaces 53a, 53a are formed on the inner circumferential surface. The double row rolling elements 54 are contained freely rollably contained between the double row outer raceway

surface 53a, 53a and the inner raceway surfaces 51a, 52a, which are arranged ~~oppositely~~opposite to ~~the outer raceway surfaces 53a, 53a~~them.

~~[0005]~~

[0006] ~~—~~The ~~hub wheel~~wheel hub 51 is formed by carbon steel including carbon of 0.40~~~~0.80% by weight and is hardened by high frequency induction hardening over a surface region (shown by cross-hatching) from a base of the wheel mounting flange 55 to the cylindrical portion 51b. The caulked portion 51c ~~is~~ remains~~ed~~ as a non-hardened portion after forging. On the other hand, the inner ring 52 is made of high carbon chrome bearing steel such as SUJ 2 and is hardened to its core by ~~dipping~~dip quenching.

~~[0006]~~

[0007] ~~—~~Thus, it is possible to realize a bearing apparatus for a wheel of a vehicle ~~of a~~with a low manufacturing cost and which has ~~having~~ sufficient durability~~,~~ to prevent the generation of cracks in the caulked portion 51c. Also, it is possible~~, and~~ to prevent the diameter of the inner ring 52, secured by the caulked portion 51c, from being deformed to an extent which ~~causin~~causes~~g~~ practical problems. In addition, it is possible to prevent the generation of damages in the inner ring 52, such as cracks, during its caulking operation, to keep the pre-load at its proper value, and also to reduce the manufacturing cost by reducing the number of parts and ~~the~~ working steps (see Japanese Laid-open Patent Publication No. 129703/1999).

~~Disclosure of the Invention~~

~~Problems to be solved by the Invention~~

~~[0007]~~

[0008] — In such a bearing apparatus for a wheel of a vehicle of the prior art, it is possible to prevent a force from being applied to the inner ring 52 by the caulking operation, however, ~~such that~~ the force causes such a~~s~~o large deformation of the diameter of the inner ring 52 that it influences the durability, ~~e.g.~~ pre-load or rolling fatigue life etc. However, when plastically deforming the end of the cylindrical portion 51b to form the caulked portion 51c, a region near the caulked portion 51c is also plastically deformed. Thus, ~~and thus~~ the inner diameter of the inner ring 52 is ~~expanded~~ radially outward expanded which generates a~~and the~~ hoop stress ~~is~~ ~~generated~~ within the inner ring 52.

~~[0008]~~

[0009] The~~In usual, the~~ inner ring 52 is usually finished by grinding the inner raceway surface 52a; ~~,~~an ~~an~~ inner circumferential surface of a inner ring ~~fitted~~fitted on the cylindrical portion 51b of the ~~hub wheel~~wheel hub 51; an~~,~~ ~~an~~ end face of the front side of the inner ring ~~contacting~~contacting a shoulder 51d of the ~~hub wheel~~wheel hub 51; an~~,~~ ~~an~~ end face of the back side~~,~~ and the outer circumferential surface on which a seal is ~~fitted~~fitted. On the contrary, a chamfered outer circumferential surface 57 of the back side ~~is~~ remains ~~remained~~ in a ~~as its turning~~ turned finished condition before heat treatment. This chamfered outer circumferential surface 57 is intended to prevent ~~of~~the generation of burrs due to ~~gouge~~gouges during the working process. Also, it is ~~and~~ to eliminate a sharp and dangerous edge. However, since its surface hardness is low before heat treatment, it is impossible to avoid the burrs or gouges during the working process.

~~[0009]~~

[0010] ——If there are burrs or gouges on the surface of the chamfered outer circumferential surface 57, a~~the~~ stress concentration will be promoted by the hoop stress caused in the inner ring 52. Thus, ~~and thus~~ the durability will be substantially ~~reduces~~reduced by cracks which are~~would be~~ caused in the inner ring 52 based on the burrs or gouges.

SUMMARY ~~OF THE INVENTION~~

~~[0010]~~

[0011]——It is therefore an object of the present ~~invention~~disclosure to provide a bearing apparatus for a wheel of a vehicle which is light weight, ~~and~~ compact, ~~and~~ has advantageous ~~in~~ durability and reliability and a method for manufacturing the bearing apparatus.

~~Means for solving problems~~

~~[0011]~~

[0012] In order to achieve ~~For achieving~~ the above, ~~there is provided, according to the present invention of claim 1,~~ a bearing apparatus for a wheel of a vehicle comprises~~comprising:~~ an inner member including a ~~hub wheel~~wheel hub with an integrally formed~~having a~~ wheel mounting flange ~~formed integrally therewith~~ at one end. ~~A thereof and a~~ cylindrical portion axially ~~extending~~extends from the wheel mounting flange. An~~, including an~~ inner ring is ~~fitted~~fitted onto the cylindrical portion. An~~; an~~ outer member is ~~arranged around the inner member. Double, and double~~ row rolling elements are~~contained~~ freely rollably contained between the inner and outer members. The~~, the~~ inner ring is~~being~~ secured in an axial direction relative to the ~~hub wheel~~wheel hub by a caulked portion. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion of the ~~hub wheel~~wheel

hub. A ~~characterized in that a~~ chamfered outer circumferential surface ~~of~~on the back side of the inner ring is formed as a cut surface machined after ~~its~~ heat treatment.

~~[0012]~~

[0013] — ~~According to the present invention, since~~Since the outer chamfered surface of the back side of the inner ring is formed as a cut surface machined after its heat treatment, it is possible to ~~perfectly~~ eliminate ~~the~~ burrs or gouges on the chamfered circumferential surface of the back side. Accordingly, it is possible to uniformly distribute the stress concentration which would ~~be~~ otherwise be caused by the hoop stress caused in the inner ring during the caulking operation due to gouges on the chamfered surface and to prevent the generation of cracks in the inner wheel. Thus, it is possible to provide a bearing apparatus for a wheel of a vehicle which is light weight, ~~and~~ compact, and has advantageous ~~in~~ durability and reliability.

~~[0013]~~

[0014] The ~~According to the present invention, the~~ ~~hub wheel~~wheel hub is directly formed on its outer circumferential surface with an inner raceway surface. The ~~and its~~ outer circumferential region from the base of the wheel mounting flange to the cylindrical portion through the inner raceway surface is hardened by high frequency induction hardening. It has a ~~as having the~~ surface hardness of 54~64 HRC. The, ~~wherein~~ caulked portion ~~is remained~~remains as a non-quenched portion with~~having~~ a surface hardness of less than 24 HRC after its forging. The, ~~and the~~ hoop stress generated within the inner ring by plastic deformation of the end of the cylindrical portion is limited to less than 300 MPa. Thus, it is possible to improve the strength and durability of the ~~hub wheel~~wheel hub and to prevent the generation of cracks in the caulked portion. In addition, it is possible to prevent excessive

deformation of the diameter of the inner ring which would cause practical problems in the inner ring. Also, it is possible and to reduce the ability of the generation of damage by the hoop stress caused by the caulking operation and to maintain the pre-load of the inner ring at a proper value. Furthermore, it is possible to reduce the manufacturing cost with the reduction of the number of parts, and working and assembling steps.

[0014]

[0015] According to the present invention, there is provided aA method for manufacturing a bearing apparatus for a wheel of a vehicle comprisingcomprises providing an inner member including a hub wheelwheel hub with an integrally formedhaving a wheel mounting flange formed integrally therewith at one end thereof and a cylindrical portion axially extending from the wheel mounting flange. An, including an inner ring is fittedfitted onto the cylindrical portion. An; an outer member is arranged around the inner member., and doubleDouble row rolling elements are contained freely rollably contained between the inner and outer members,. The the inner ring being is secured in an axial direction relative to the hub wheelwheel hub by a caulked portion. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion of the hub wheelwheel hub. A, characterized in that a chamfered outer circumferential surface of the back side of the inner ring is re-cut after its is heat treatedment. Thus, it is possible to uniformly distribute the stress concentration which would be otherwise be caused by the hoop stress caused in the inner ring during the caulking operation due to gouges on the chamfered surface. Also, it is possible and to prevent the generation of cracks in the inner ringwheel. Thus, it is possible to improve the strength and durability of the inner ring.

~~[0015]~~

[0016] ~~According to the present invention, since~~Since the chamfered outer circumferential surface of the back side of the inner ring is re-cut by a cutting tool of hardened steel after it is~~its~~ heat treated~~ment~~, it is possible to carry out highly~~high~~ accurate~~accuracy~~ machining of the chamfered portion without the influence of deformation due to the heat treatment.

~~[0016]~~

[0017] ~~According to the present invention, since~~Since the chamfered outer circumferential surface of the back side of the inner ring is re-cut by a grinding stone at least simultaneously with an outer circumferential surface of a larger diameter end of the inner ring, it is possible to carry out ~~high~~highly accurate ~~accuracy~~ machining of the chamfered portion without the influence of deformation due to the heat treatment. In addition, since the chamfered portion can be smoothly finished, it is possible to reduce ~~the~~ stress concentration ~~therein~~.

~~[0017]~~

[0018] ~~According to the present invention, since~~Since the chamfered outer circumferential surface of the back side of the inner ring is re-cut by a grinding stone at least simultaneously with a backside end face ~~16~~ of the front side and an inner raceway surface ~~51a~~ of the inner ring, it is possible to improve the accuracy of machining, to reduce working steps and to realize a ~~low~~lower manufacturing cost.

~~Effect of the Invention~~

~~[0019]~~

[0019] ~~According to the present invention, there is provided a~~ A bearing apparatus for a wheel of a vehicle ~~comprising~~comprises: an inner member which

includesincluding a hub wheelwheel hub with an integrally formed having a wheel mounting flange formed integrally therewith at one end thereof and a cylindrical portion axially extending from the wheel mounting flange. An, including an inner ring is fittedfitted on the cylindrical portion. An; an outer member is arranged around the inner member. Double, and double row rolling elements arecontained freely rollably contained between the inner and outer members. The, the inner ring beingis secured in an axial direction relative to the hub wheelwheel hub by a caulked portion. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion of the hub wheelwheel hub. A characterized in that a chamfered outer circumferential surface of the back side of the inner ring is formed as a cut surface machined after it isits heat treatedment. Thus, it is possible to perfectly eliminate the burrs or gouges on the chamfered circumferential surface of the back side. Accordingly, it is possible to uniformly distribute the stress concentration which would be otherwise be caused by the hoop stress caused in the inner ring during the caulking operation due to gouges on the chamfered surface. Also, it is possible and to prevent the generation of cracks in the inner wheel. Thus, it is possible to provide a bearing apparatus for a wheel of a vehicle which is light weight, and compact and has advantageous in durability and reliability.

[0019]

[0020] A Further according to the present invention, there is provided a method for manufacturing a bearing apparatus for a wheel of a vehicle comprisescomprising providing a bearing apparatus with the following. An an inner member which includesincluding a hub wheelwheel hub with an integrally formedhaving a wheel mounting flange formed integrally therewith at one end thereof

and a cylindrical portion axially extending from the wheel mounting flange. An~~,~~ ~~including an~~ inner ring is ~~fitted~~fitted onto the cylindrical portion. An~~;~~ ~~an~~ outer member is arranged around the inner member. Double~~,~~ ~~and double~~ row rolling elements are~~contained~~ freely rollably contained between the inner and outer members. The~~,~~ ~~the~~ inner ring ~~being~~is secured in an axial direction relative to the ~~hub wheel~~wheel hub by a caulked portion. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion of the ~~hub wheel~~wheel hub. The next step includes recutting~~,~~ ~~characterized in that~~ a chamfered outer circumferential surface of the back side of the inner ring ~~is re-cut~~ after it is~~its~~ heat treated~~ment~~. Thus, it is possible to uniformly distribute the stress concentration which would ~~be~~ otherwise be caused by the hoop stress caused in the inner ring during the caulking operation due to gouges on the chamfered surface. Also, it is possible ~~and~~ to prevent the generation of cracks in the inner ring~~wheel~~. Thus, it is possible to improve the strength and durability of the inner ring.

~~Best mode for carrying out the Invention~~

~~[0020]~~

[0021] A~~The best mode for carrying out the present invention is a~~ bearing apparatus for a wheel of a vehicle ~~comprising:~~comprises an inner member which includes a ~~including a hub wheel~~wheel hub with an integrally formed ~~having a~~ ~~w~~wheel mounting flange ~~formed integrally therewith~~ at one end ~~thereof~~ and a cylindrical portion axially extending from the wheel mounting flange. An ~~, including an~~ inner ring is ~~fitted~~fitted on the cylindrical portion. An~~;~~ ~~an~~ outer member is arranged around the inner member. Double~~,~~ ~~and double~~ row rolling elements are~~contained~~ freely rollably contained between the inner and outer members. The~~,~~

~~the~~ inner ring ~~being~~is secured in an axial direction relative to the ~~hub wheel~~wheel hub by a caulked portion. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion of the ~~hub wheel~~wheel hub. A ~~characterized in that a~~ chamfered outer circumferential surface of the back side of the inner ring is formed as a cut surface machined after it is~~its~~ heat treated~~ment~~.

[0022] Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS ~~BRIEF DESCRIPTION OF THE DRAWINGS~~

[0023] Additional advantages and features of the present ~~invention~~disclosure will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, wherein:

[0024] Fig. 1 is a longitudinal section view of~~showing~~ a first embodiment of a~~the~~ wheel bearing apparatus. ~~for a wheel of the present invention;~~

[0025] Fig. 2 is an enlarged partial view of Fig. 1.~~;~~

[0026] Fig. 3 is an explanatory cross-section view showing a method for re-cutting ~~of~~ a chamfered outer circumferential surface. ~~according to the present invention;~~

[0027] Fig. 4 is another explanatory cross-section view showing the other re-cutting.~~;~~

[0028] Fig. 5 is a longitudinal section view showing a second embodiment of a~~the~~ wheel bearing apparatus ~~for a wheel of the present invention; and~~.

[0029] Fig. 6 a longitudinal section view of~~showing~~ a wheel bearing apparatus for a wheel of a vehicle of the prior art.

DETAILED DESCRIPTION ~~OF THE PREFERRED EMBODIMENTS~~

[0030] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses.

~~First embodiment~~

~~[0021]~~

[0031] Fig. 1 shows a first embodiment of a bearing apparatus for a wheel of a vehicle~~ of the present invention and~~ Fig. 2 is an enlarged partial view of Fig. 1. In the description below, the~~a~~ term "outboard side" of the apparatus denotes a side which is positioned outside of the vehicle body. The ~~and a~~ term "inboard side" of the apparatus denotes a side which is positioned inside of the body when the bearing apparatus is mounted on the vehicle body.

~~[0022]~~

[0032] The illustrated bearing apparatus for a wheel of a vehicle has~~comprises~~ an inner member 1, an outer member 10 and double row rolling elements (balls) 6, 6 ~~retained~~ freely rollably retained between the inner and outer members 1, 10. The inner member 1 ~~comprises~~includes a ~~hub wheel~~wheel hub 2 and an inner ring 3 press-~~fitted~~fit ~~on~~onto the ~~hub wheel~~wheel hub 2. The ~~hub wheel~~wheel hub 2 is integrally formed with a wheel mounting flange 4 ~~for~~to ~~mounting~~mount a wheel (not shown) on its outer peripheral surface at the end of the outboard side. Hub bolts 5, ~~to for securing~~ secure the wheel on the flange 4, are equidistantly arranged along the periphery of the flange 4. The ~~hub wheel~~wheel hub 2 is also formed with one inner raceway surface on its outer circumferential surface. ~~with one inner raceway~~

~~surface and has a~~A cylindrical portion 2b axially ~~extending~~extends from the inner raceway surface 2a on the wheel hub 2. The inner ring 3 is ~~fitted~~fit ~~on~~onto the cylindrical portion 2b. The inner ring 3 includes the other inner raceway surface 3a on ~~and formed on~~ its outer circumferential surface. ~~with the other inner raceway surface 3a.~~ The inner ring 3 is secured in an axial direction relative to the ~~hub wheel~~wheel hub 2 by a caulked portion 2c. The caulked portion 2c is formed by radially outwardly deforming the end of the cylindrical portion 2b of the ~~hub wheel~~wheel hub 2. According to this embodiment, since it is unnecessary to control the amount of pre-load by using a fastening nut as in the prior art, it possible to provide a self-retaining structure which can keep the proper pre-load of the bearing for a long term.

~~[0023]~~

[0033] The outer member 10 is integrally formed with a body mounting flange 10b on its outer circumferential surface. The outer member ~~with a body mounting flange 10b and~~ is also formed with double row outer raceway surfaces 10a, 10a on its inner circumferential surface ~~with double row outer raceway surfaces 10a, 10a~~. Double row rolling elements 6, 6 are freely rollably held by cages 7, 7 between the outer and inner raceway surfaces 10a, 10a; 2a, 3a. Seals 8, 9 are arranged at the ends of the outer member 10. The seals 8, 9 ~~to~~ prevent ~~leak~~leakage of lubricating grease contained within the bearing as well as the ingress of rain water or dusts from the outside.

~~[0024]~~

[0034] Although the illustrated bearing apparatus is ~~the~~a so-called third generation type ~~wherein which~~ the inner raceway surface 2a is directly formed on the

outer circumferential surface of the ~~hub wheel~~wheel hub 2, the present ~~invention~~disclosure is not limited to only this type ~~thereto~~ and can be applied to ~~the~~a first or second generation type ~~where~~in ~~which~~ one pair of inner rings are press-~~fitted~~fit ~~on~~onto the cylindrical portion of the ~~hub wheel~~wheel hub. In addition, although the illustrated bearing apparatus uses ~~the~~ double row angular ball bearing, it is possible to use other bearing, such as a ~~e.g.~~ double row tapered roller bearing using tapered rollers as the rolling elements.

~~[0025]~~

[0035] The ~~hub wheel~~wheel hub 2 is made of medium carbon steel which ~~includes~~including carbon of 0.40~~~~0.80% by weight such as S53C. It is ~~and~~ hardened to a~~as having~~ surface hardness of 54~~~~64 HRC by high frequency induction hardening at the inner raceway surface 2a of the outboard side, a seal land portion ~~with~~ which contacts the seal 8 ~~contacts~~, and the axially extending cylindrical portion 2b. The caulked portion 2c ~~is remained~~remains as a non-quenched portion with~~having~~ a surface hardness of less than 24 HRC after it is~~its~~ forged~~ing~~. The inner ring 3 is made of high carbon chrome bearing steel, such as SUJ2, and is hardened to its core by dip~~ping~~ quenching to have a surface hardness of 54~64 HRC. The thickness of the inner ring 3 and the caulked portion 2c as well as the caulking load are properly set so that the hoop stress caused within the inner ring 3 is limited to less than 300 MPa.

~~[0026]~~

[0036] Accordingly, ~~Thus~~ it is possible to improve the strength and durability of the ~~hub wheel~~wheel hub 2 and to prevent the generation of cracks in the caulked portion 2c. In addition, it is possible to prevent excessive deformation of the

diameter of the inner ring 3 which would cause a practical problem in the inner ring 3. It is also possible ~~and~~ to reduce the ability of the generation of damage by the hoop stress caused by the caulking operation. Further, it is possible ~~and~~ to maintain the pre-load of the inner ring 3 at a proper value. Furthermore, it is possible to reduce the manufacturing cost with the reduction of the number of parts, and working and assembling steps.

~~[0027]~~

[0037] The outer member 10 is made of medium carbon steel which includes~~including~~ carbon of 0.40~~~~0.80% by weight, such as S53C. Its ~~and its~~ double row outer raceway surfaces 10a, 10a and ~~the~~ inner circumferential surface of the outer member 10 ~~to~~ which contact the seals 8, 9 ~~contact~~ are hardened by high frequency induction quenching to have a surface hardness of 54~~64 HRC.

~~[0028]~~

[0038] In this embodiment, the chamfered outer circumferential surface 11 of the back side of the inner ring 3 is formed by a cut surface of hardened steel machined after it is heat treated~~ment~~ as shown in Fig. 2. That is, the chamfered surface and other portion of the inner ring 3 are cut by turning and then its predetermined portion is ground after heat treatment, but only the chamfered outer circumferential surface of the back side is re-cut before the grinding process. The re-cutting process can be carried out after the grinding process, however, it is preferable to carry out the re-cutting process before the grinding process since gouges are~~would be~~ sometimes caused on the inner raceway surface 3a during the cutting process of the chamfered portion 11.

~~[0029]~~

[0039] Fig. 3 is an explanatory view showing such a re-cutting method. The reference working surface of the heat treated inner ring 3' is set by abutting the end face 16 of the front side. Next, ~~and then~~ the chamfered surface 11 of the back side is cut, by turning using a bite 14. The cutting bite 14 ~~used~~ may include ~~be that to which~~ a cemented carbide chip 15 formed to have ~~as having~~ a desired configuration and dimension and it is bonded to the bit 14. The ~~or the~~ chamfered surface may also be machined with use of a NC lathe. The feeding amount of bite for machining the chamfered surface 11 is set within about 1~3 mm both in axial and radial directions.

~~[0030]~~

[0040] In addition to this method, there is a method for simultaneous grinding the chamfered portion 11 during grinding of the inner raceway surface 3a etc. For example as shown in Fig. 4, ~~firstly~~ the reference working surface is set by abutting the end face 18 of the back side of the heat treated inner ring 3' to a backing plate 19 of a grinding machine. The ~~and then the~~ end face 16 of the front side, the inner raceway surface 3a, the outer circumferential surface 17 of a larger diameter end and the chamfered portion 11 are simultaneously ground by a single grinding stone.

~~[0031]~~

[0041] More particularly, each portion of the inner ring 3' is ground by plunge cutting with the end face 18 of the back side ~~being~~by magnetic ~~ally attracted~~attraction and then rotating the grinding stone 20 in the ~~a~~ same rotational direction as ~~that of~~ the inner ring 3' and feeding it at a predetermined inclined direction. This makes it possible to reduce the number of working steps and to assure the ground surfaces of having high accuracy since desirable relative circumferential speed can be obtained between each working surface and the grinding stone 20. In addition, it is possible to

reduce the stress concentration at the edge portion between the circumferential surface 17 and the chamfered portion 11 since they are connected via a smooth rounded corner without any edge therebetween.

~~[0032]~~

[0042] According to this embodiment, since the chamfered portion 11 of the back side of the inner ring 3' is re-cut by the cutting bite 14 or the grinding stone 20, after it is~~its~~ heat treated~~ment~~, it is possible to ~~perfectly~~ eliminate ~~the~~ burrs or gouges caused on the chamfered surface in prior working steps. Accordingly, the stress concentration which would be caused by the gouges on the chamfered surface 11 can be distributed or reduced and thus the generation of cracks on the inner ring 3 is prevented to improve the durability of the inner ring 3.

~~Second embodiment~~

~~[0033]~~

[0043] Fig. 5 is a longitudinal section view ~~showing~~of a second embodiment of the bearing apparatus~~ for a wheel of the present invention~~. Same reference numerals are used ~~for~~to ~~designating~~designate the same parts having the same functions used in the first embodiment.

~~[0034]~~

[0044] The ~~hub wheel~~wheel hub 21 is integrally formed with a wheel mounting flange 4 ~~for~~to ~~mounting~~ mount a wheel (not shown) on its outer peripheral surface at the end of the outboard side. The ~~hub wheel~~wheel hub 21 is formed with one inner raceway surface 2a on its outer circumferential surface. A serration (spline) 22 is formed ~~with one inner raceway surface 2a and~~ on its inner circumferential surface. The ~~with a~~ serration (spline) 22 receives~~into which~~ an outer joint member of a

constant velocity universal joint (not shown) ~~is fitted~~. The ~~hub wheel~~wheel hub 21 has a cylindrical portion 2b axially extending from the inner raceway surface 2a. The inner ring 3 is secured in an axial direction relative to the ~~hub wheel~~wheel hub 21 by a caulked portion 2c. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion 2b of the ~~hub wheel~~wheel hub 21.

~~[0035]~~

[0045] Similarly to the previously described first embodiment, since the chamfered outer circumferential portion 11 of the back side of the inner ring 3 is re-cut after heat treatment, the burrs or gouges caused on the chamfered surface 11 during previous working steps can be ~~perfectly~~ eliminated. Accordingly, it is possible to uniformly distribute the stress concentration which would be otherwise caused by the hoop stress caused in the inner ring during the caulking operation due to gouges on the chamfered surface. Also, it is possible ~~and~~ to prevent the generation of cracks in the inner wheel. Thus, it is possible to provide a bearing apparatus for a wheel of a vehicle which ~~is~~has advantageous ~~in~~ durability and reliability.

~~Applicability in industry~~

~~[0036]~~

[0046] The bearing apparatus for a wheel of a vehicle can be applied to those~~that~~ having ~~the~~ self-retaining structure of the first, second and third generation types where~~in which~~ the inner ring is press-~~fitted~~fit ~~on~~onto the cylindrical portion of the ~~hub wheel~~wheel hub and firmly secured ~~thereon~~ by caulking the end of the cylindrical portion.

~~[0037]~~

[0047] The present ~~invention~~disclosure has been described with reference to the preferred embodiments. Obviously, modifications and alternations will occur to those of ordinary skill in the art upon reading and understanding the preceding detailed description. It is intended that the present ~~invention~~disclosure be construed to~~as~~ include ~~including~~ all such alternations and modifications insofar as they come within the scope of the appended claims or ~~the~~their equivalents ~~thereof~~.

CLAIMS

What is claimed is:

1. A bearing apparatus for a wheel of a vehicle comprising:

an inner member ~~(1)~~ including a ~~hub wheel~~wheel hub ~~(2, 21)~~ having an integrally formed ~~a~~ wheel mounting flange ~~(4) formed integrally therewith~~ at one end ~~thereof~~ and a cylindrical portion ~~(2b)~~ axially extending from the wheel mounting flange ~~(4)~~, ~~including~~ an inner ring ~~(3) fitted~~fitted on the cylindrical portion ~~(2b)~~;

an outer member ~~(10)~~ arranged around the inner member ~~(1),~~;

~~and~~ double row rolling elements ~~(6, 6) contained~~ freely rollably contained between the inner and outer members;

~~(1, 10),~~ the inner ring ~~(3)~~ being secured in an axial direction relative to the ~~hub wheel~~wheel hub ~~(2, 21)~~ by a caulked portion, said caulked portion ~~(2c)~~ formed by radially outwardly deforming the end of the cylindrical portion ~~(2b)~~ of the ~~hub wheel~~wheel hub; and

~~(2, 21) characterized in that~~ a chamfered outer circumferential surface ~~(11)~~ of a~~the~~ back side of the inner ring ~~(3)~~ is formed as a cut surface machined after ~~its~~ heat treatment of the inner ring.

2. The ~~A~~ bearing apparatus for a wheel of a vehicle according to~~of~~ claim 1 wherein the ~~hub wheel~~wheel hub ~~(2, 21)~~ is ~~directly~~ formed with an inner raceway surface on its outer circumferential surface ~~with an inner raceway surface (2a)~~ and said wheel hub~~its~~ outer circumferential region from a~~the~~ base of the wheel mounting flange ~~(4)~~ to the cylindrical portion ~~(2b)~~ through the inner raceway surface ~~(2a)~~ is hardened by high frequency induction hardening to have a~~as having the~~ surface hardness of 54~64 HRC, said~~wherein~~ caulked portion ~~(2c) is remained~~ remains as a non-quenched portion having a surface hardness less than 24 HRC after ~~its~~ forging, and ~~wherein the~~ hoop stress generated within the inner ring ~~(3)~~ by plastic deformation of the end of the cylindrical portion ~~(2b)~~ is limited to less than 300 MPa.

3. ~~A~~ method for manufacturing a bearing apparatus for a wheel of a vehicle comprising:

providing an inner member ~~(1)~~ including a ~~hub wheel~~wheel hub ~~(2, 21)~~ having a~~an integrally formed~~ wheel mounting flange ~~(4) formed integrally therewith~~ at one end ~~thereof~~ and a cylindrical portion axially extending from the wheel mounting flange ~~(4), including~~ an inner ring ~~(3) fitted~~fitted on the cylindrical portion ~~(2b)~~; an outer member ~~(10)~~ arranged around the inner member ~~(1)~~, and double row rolling elements ~~(6, 6) contained~~ freely rollably contained between the inner and outer members ~~(1, 10),~~;

securing the inner ring ~~(3) being secured~~ in an axial direction relative to the ~~hub wheel~~wheel hub;

~~(2, 21) by a caulked portion (2c) formed by r~~radially outwardly deforming the end of the cylindrical portion ~~(2b)~~ of the ~~hub wheel~~wheel hub forming a caulked portion;

recutting ~~(2, 21), characterized in that~~ a chamfered outer circumferential surface ~~(11) of~~of a~~the~~ back side of the inner ring ~~(3) is re-cut~~ after ~~its~~ heat treatment of said inner ring.

4. The ~~A~~ method for manufacturing a bearing apparatus for a wheel of a vehicle according to ~~of~~ claim 3 wherein said recutting of the chamfered outer circumferential surface ~~(11)~~ of the back side of the inner ring ~~(3)~~ is re-cut by a hardened steel cutting tool ~~(14) of hardened steel~~ after said~~its~~ heat treatment.

5. The ~~A~~ method for manufacturing a bearing apparatus for a wheel of a vehicle according to~~of~~ claim 3 wherein said recutting of the chamfered outer circumferential surface ~~(11)~~ of the back side of the inner ring ~~(3)~~ is re-cut by a grinding stone and~~(20) at~~ at least simultaneously cutting~~with~~ an outer circumferential surface ~~(17)~~ of a larger diameter end of the inner ring ~~(3)~~.

6. The ~~A~~ method for manufacturing a bearing apparatus for a wheel of a vehicle according to~~of~~ claim 5 wherein said recutting of the chamfered outer circumferential surface ~~(11)~~ of the back side of the inner ring ~~(3)~~ is re-cut by a grinding stone and ~~(20)~~ at least simultaneously cutting~~with~~ a backside end face ~~(16)~~ of a~~the~~ front side of the inner ring and an inner raceway surface ~~(51a)~~ of the inner ring.

ABSTRACT

A ~~The present invention relates to a~~ bearing apparatus for a wheel of a vehicle for rotatably supporting a wheel of a vehicle relative to a suspension system. The bearing apparatus~~, and more particularly to a bearing apparatus for a wheel of vehicle intended to improve~~ improves the durability of an inner ring ~~fitted~~fit ~~on~~onto a ~~hub wheel~~wheel hub. The~~, and a method for manufacturing the bearing apparatus. According to the present invention, there is provided a~~ bearing apparatus for a wheel of a vehicle ~~has~~~~comprising~~ an inner member which ~~including~~includes a ~~hub wheel~~wheel hub with an integrally formed~~having a~~ wheel mounting flange ~~formed integrally therewith~~ at one end ~~thereof~~ and a cylindrical portion axially extending from the wheel mounting flange. An~~, including an~~ inner ring is ~~fitted~~fit ~~on~~onto the cylindrical portion. An~~; an~~ outer member is arranged around the inner member~~,~~. Double~~ and double~~ row rolling elements are~~contained~~ freely rollably contained between the inner and outer members. The~~, the~~ inner ring ~~being~~ is secured in an axial direction relative to the ~~hub wheel~~wheel hub by a caulked portion. The caulked portion is formed by radially outwardly deforming the end of the cylindrical portion of the ~~hub wheel~~wheel hub. A ~~characterized in that a~~ chamfer~~ed~~ is formed on an outer circumferential surface of ~~the~~a back side of the inner ring. The chamfer is formed as a cut surface machined after ~~its~~ heat treatment of the inner ring.